CHAPTER 5 GROUNDWATER DEVELOPMENT PLAN

5.1 Basic Policy of the Plan

5.1.1 Importance of Plan

Proposed plan for groundwater development, conservation and management was formulated by objective and scientific approach, based on i) data of natural condition (meteorology, hydrology and hydrogeology) that were accumulated by reliable observation and measurement, ii) well inventory and iii) forecast of future water demand.

According to the results of surveys and analyses that were carried out in this Study before formulation of this plan, $20m^3/s$ of groundwater in annual average is occurring in the Study Area. This volume corresponds to 18% of annual precipitation (800mm). Currently $3.7m^3/s$ of groundwater, which is 20% of groundwater occurrence, is used. This groundwater is used for important social and economic activities such as irrigation for flower production, industrial use and water supply. In this plan, strategic methods are proposed which ensure sustainable groundwater use and safety groundwater development depending on future water demand. This plan can be guidelines of sustainable groundwater use for prosperous social and economic activities of people living in Bogotá Plain. This plan was formulated with target year of 2015, and should be successively revised according to change of water demands corresponding to social and economic situation and newly obtained data by hydrogeological surveys that will be implemented.

5.1.2 Basic Policy of Groundwater Development

(1) Optimum Groundwater Development Corresponding to Safe Yield

In new groundwater development plans, production wells should be designed considering safe yield (60% of groundwater recharge) by basin where groundwater levels will be affected by this groundwater development. Volume of groundwater by new development should be less than remaining safe yield (= safe yield – current pumping rate) by basin. Groundwater development of small/medium-scale, which will cause only small influence, should be planed considering remaining safe yield by basin. Groundwater development of large-scale, which will cause large influence on several basins, should be planed considering total of remaining safe yield of these basins. However, before the implementation of the large-scale project, change of groundwater flow and groundwater levels by this project must be studied by groundwater simulation etc in order to confirm that this plan is safety.

Table-5.1 Remaining Safe Yield by Basin

Basin	Safe Yield (mm/year) *1)	Current Yield (mm/year)	Remaining Safe Yield of basin		Possible No of standard wells to be drilled*2)
			(mm/year)	(1,000 m3/day)	
Bogotá 1-3	63	42	21	39	390
Bogotá 4-6	90	72	18	11	114
Bogotá 7-9	37	18	19	28	290
Bojaca	77	36	41	24	246
Chicu	112	122	(-10)	(-3)	(-37)
Frio	60	23	37	19	197
Neusa	112	7	105	124	1,243
Sisga	86	0	86	35	358
Muna	35	4	31	10	109
Subachoque 1	43	3	40	3	35
Subachoque 2	90	52	38	40	402
Teusaca	100	15	85	82	822
Tomine	66	1	65	65	655
Tunjuelito	198	10	188	208	2,081
All Study Area	86	27	59	689	6,899

Note-*1) Safe yield = groundwater recharge x 60%
Note-*2) Yield of standard well is $100m^3/day$

(2) Basic Policy of Groundwater Development by Aquifer

There are three aquifers (Quaternary, Tertiary and Cretaceous) in each basin of the Study Area. Groundwater moves continuously among these aquifers. Safe yield was calculated as total volume of groundwater that can be pumped up from three aquifers. Therefore, total pumping volume should be less than safe yield by each basin in new groundwater development. Basic policy of groundwater development for each aquifer is as follows.

<Quaternary>

Quaternary aquifer is classified into two areas, i) area where groundwater has been already developed fully and ii) area with little current development. In the area of fully developed, new groundwater development should be subject to restriction, and groundwater conservation is necessary to continue the current groundwater use. Besides, in area with little current groundwater development, groundwater development can be promoted from now on depending on its water demand.

<Tertiary>

Only little water can be pumped up from wells of Tertiary. Small-scale groundwater development is possible in the future in Tertiary aquifer as done at present.

<Cretaceous>

Cretaceous System of the Study Area distributes in mountains/hills and deep part of ground in entire Bogotá Plain. This Cretaceous system has high capacity of groundwater production. However, only little groundwater of Cretaceous aquifer has been developed in every basin of the Study Area so far. It is concluded that Cretaceous aquifer is most promising in new groundwater development. However, groundwater development of deep Cretaceous aquifer will cost high and has considerable risks. Besides, groundwater development of Cretaceous aquifer that distributes in mountains/hills has little risks and has high possibility. Consequently, new groundwater development of Cretaceous aquifer should be implemented in mountains/hills of Bogotá Plain depending on water demand. As Cretaceous aquifer distributes entire Study Area and has high production capacity, this aquifer is suitable for large-scale groundwater development. Moreover, Cretaceous aquifer extends beyond river basins, and there is possibility that groundwater can be developed more than safe yield of a basin where groundwater development sites locate.

(3) Basic Policy of Groundwater Development by Basin

Groundwater development by basin should be planed based on comparison between volume of the current pumping and safe yield by basin. Table-5.2 shows the current level of groundwater utilization.

Table-5.2 Current Level of Groundwater Utilization

Current groundwater utilization	Ratio of utilization	Basin
Area of high groundwater use	More than 40%	Bogotá 1-3、Bogotá 4-6、Chicu
Area of medium groundwater use	20%-40%	Bogotá 7-9、Bojaca、Frio、Subachoque
Area of low groundwater use	Less than 20%	Neusa、Sisga、Teusaca、Tomine、Tunjuelito

Note) Ratio of groundwater utilization = Volume of groundwater use÷Safe Yield

<Area of high groundwater use>

In this area, new groundwater development should be subject to restriction. Moreover, groundwater conservation is necessary to continue current groundwater use.

<Area of medium groundwater use>

There is groundwater development potential still remaining in this area. However, careful planning for new groundwater development is necessary based on safe yield. At the same time, groundwater conservation plan should be formulated.

<Area of low groundwater use >

In this area, the volume of current pumping is much less than safe yield. Groundwater development should be strongly promoted depending on water demand of these areas.

5.1.3 Basic Policy of Groundwater Conservation

Areas where groundwater conservation is necessary are classified as shown below.

1) Area where level of groundwater utilization is middle to high.

2) Area where large-scale groundwater development is planed

Groundwater conservation plan is proposed for each area as shown below.

(1) Area where Level of Groundwater Utilization is Middle to High

Central and western part of Bogotá Plain is classified into this area. Agricultural production is high and level of groundwater utilization is also high in this area. Groundwater conservation is necessary to continue the current groundwater use. Method of conservation is proposed as follows.

<Groundwater artificial recharge>

Groundwater artificial recharge is proposed to compensate groundwater storage of Quaternary aquifer that was consumed by pumping. Excess river water in tributaries of up-stream of the central and western Bogotá Plain will be stored in settling ponds. This water will be injected into Quaternary aquifer though recharge wells. This artificial recharge will contribute to stabilization of water supply for agriculture use in Bogotá Plain, taking in account the water quality.

<Reduction of loads on groundwater resource caused by water use>

In order to reduce the loads on groundwater resource caused by water use, it should be promoted; i) use of alternative water resource for flower production (reuse of drained water, use of rainfall and river water of Bogotá main River), ii) change of sites for new flower production, iii) promotion of study on improvement of irrigation efficiency.

(2) Area where Large-scale Groundwater Development is planed

Groundwater recharge to Cretaceous aquifer by rainfall is limited, though Cretaceous aquifer has high productivity. Consequently, in large-scale groundwater development, artificial recharge using surplus river water should be implemented in order to minimize influence by development. Conceptual model of artificial recharge is shown in Figure-5.1.

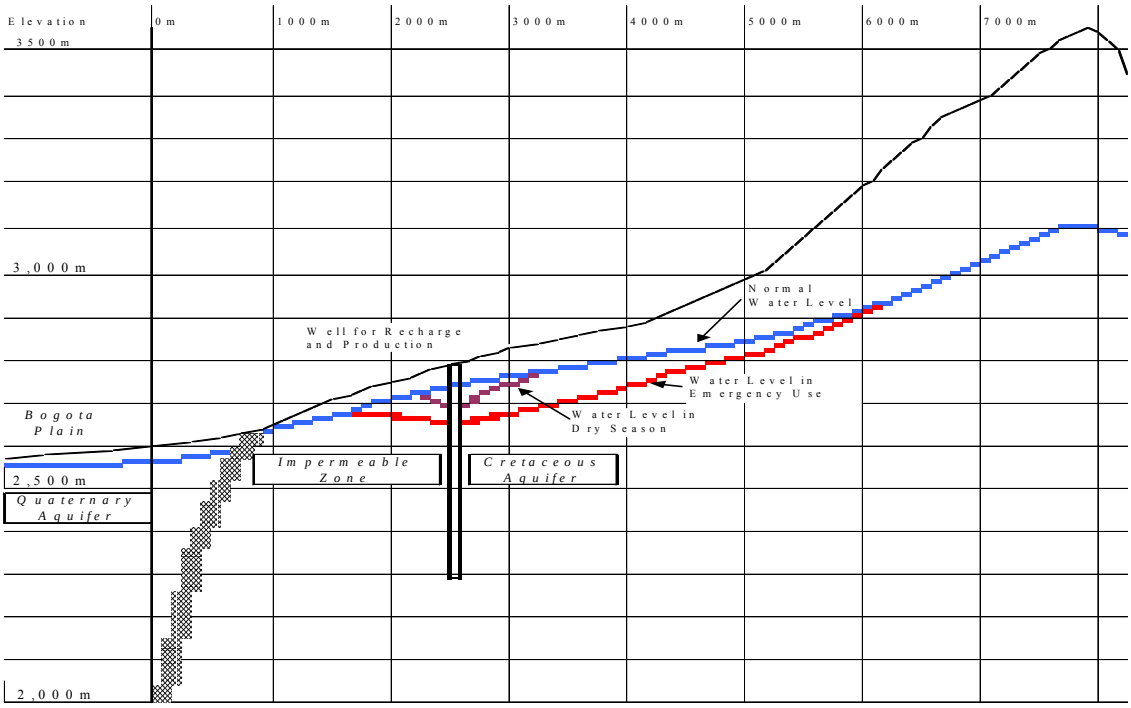

Figure-5.1 Concept of Artificial Recharge

5.2 Demand Projection of Groundwater

(1) Water Supply System of EAAB

Actual water supply and production capacity of EAAB in 2001 was 14.6m^3/second that equaled to 56 % of year 2001 production capacity (This has enlarged to 26.3m^3/second in 2001 due to newly constructed El Dorado Plant). The water supply volume has been declining due to decrease in consumption caused by such as 1) a sharp rise of tariff, 2) a reduction of water transfer pressure, 3) a campaign of saving water and 4) a nationwide economic slowdown.

The production capacity was judged enough until year 2015 for the highest demand of the projection. EAAB may hold sufficient supply capacity against current and future demand until 2015. Nevertheless, EAAB relies almost half of the production capacity on Wiesner Plant, water resources of which are located at a distant place. Consequently, the Plant is regarded vulnerable against disasters. So, it is widely concerned to develop and keep safe and reliable water sources against disasters as well as emergencies such as droughts that may occur to the Bogotá River and other rivers.

Demand projection of EAAB (Year1999) is presented in Table-5.3.

Table-5.3 EAAB Demand Projection (medium demand level)

Year	2000	2005	2010	2015	2020
m^3/second	15.3	18.1	20.3	23.0	25.9

(2) Groundwater Demand of the Study Area

Groundwater is supplied for domestic use in 12 municipalities (39% of all municipalities of the Study Area), for non-domestic use in 18 municipalities (58%), for flower irrigation in 24 municipalities (77%) and for other irrigation in 20 municipalities (71%). It is assumed that irrigation use would be the most predominant in the Study Area. The three largest groundwater demand areas by river basin are: 1) Subachoque River Basin (2), 2) Chicu River Basin, and 3)

Bogotá River Basin (3) – West. Groundwater demand is estimated at 403,000m^3/day (4.65m^3/s) in target year of 2015, based on the current trend of groundwater use, as shown in Table-5.4.

Table-5.4 Total Water Demand of the Study Area

Water Use		Water Source	2000		2015	
			1000m^3/day	m^3/second	1000m^3/day	m^3/second
Municipal Water	Domestic	Surface Water	1,103	12.77	1,506	17.43
		Groundwater	15	0.17	23	0.26
		Total	1,118	12.94	1,529	17.69
	Non-domestic	Surface Water	310	3.58	583	6.75
		Groundwater	25	0.29	45	0.52
		Total	335	3.87	628	7.27
	Total	Surface Water	1,413	16.35	2,089	24.18
		Groundwater	**40**	**0.46**	**68**	**0.78**
		Total	1,453	16.81	2,157	24.96
Irrigation Water	Flower	Surface Water	30	0.35	40	0.47
		Groundwater	120	1.39	162	1.87
		Total	150	1.74	202	2.34
	Agriculture	Surface Water	909	10.52	980	11.33
		Groundwater	160	1.85	173	2.00
		Total	1,069	12.37	1,152	13.33
	Total	Surface Water	939	10.87	1,020	11.80
		Groundwater	**280**	**3.24**	**335**	**3.87**
		Total	1,219	14.11	1,355	15.67
Total		Surface Water	2,352	27.22	3,109	35.98
		Groundwater	**320**	**3.70**	**403**	**4.65**
		Total	2,672	30.95	3,512	40.63

(3) Water Demand in the Development and Conservation Plan Area

<Bogotá Eastern Hill Project>

Development area consists of two areas; Eastern Hills of Bogotá City and Yerba Buena. Eastern Hills of Bogotá City consists of three areas; 1) Bogotá City eastern hills, 2) Suba hills and 3) Soacha hills. Population of the Area is estimated to reach 750,000persons in 2015 or 7% of the total population of Bogotá D.C. and Soacha. Water demand in the Eastern Hills of Bogotá City is estimated at 1.145m^3 in 2015 as shown in Table-5.5.

Table-5.5 Groundwater Demand Projection of Eastern Hills of Bogotá City

Location	Site	Name of Tank	2000	2005	2010	2015
Vitelma	Vitelma	El Consuelo	0.035	0.036	0.036	0.037
Santana & Chico	Usaquen	Usaquen	0.024	0.024	0.024	0.024
	Chico	Chico	0.072	0.078	0.084	0.091
Cerros Norte	Codito	Codito	0.025	0.027	0.030	0.033
	Soratama	Soratama	0.008	0.008	0.007	0.007
	Cerro Norte	Cerro Norte	0.024	0.026	0.028	0.031
	Bosque Pino	Bosque Pino	0.001	0.001	0.001	0.002
	Bosque Medina	Bosque Medina	0.005	0.005	0.005	0.005
	Unicerros	Unicerros	0.019	0.018	0.018	0.017
Soacha	Sierra Morena III	Sierra Morena III	0.148	0.184	0.228	0.283
	Julio Rincon	Julio Rincon	0.178	0.184	0.228	0.283
	Santillana	Santillana	0.126	0.156	0.194	0.241
Subtotal			0.667	0.775	0.908	1.069
Suba	Medio Suba	Medio Suba	0.046	0.046	0.046	0.046
	Alto de Suba	Alto de Suba	0.023	0.026	0.028	0.030
Subtotal			0.069	0.071	0.074	0.076
Total			0.736	0.846	0.981	1.145

Besides, groundwater development volume in the Yerba Buena is planed at 1m^3/second. The development volume will benefit to 550,000 persons. Thus the total groundwater demand of the two areas is estimated at 2.145 m^3/second in 2015. Total beneficiaries will reach 1,300,000 persons.

< Bogotá Western Plain Project>

The conservation plan in Western Area of Bogotá Plain contains six river basins. In the Area the irrigation use for such as flower and agriculture is overwhelming for groundwater demand, which is estimated at 2.611 m^3/second in 2015 as shown in Table-5.6.

Table-5.6 Groundwater Demand on Irrigation of Bogotá Western Plain Project

River Basin	Flower		Agriculture		Total	
	2000	2015	2000	2015	2000	2015
1. Bogotá (3)- Western	0.175	0.236	0.293	0.316	0.468	0.552
2. Bogotá (7)	0.205	0.267	0.087	0.094	0.292	0.361
3. Bojacá	0.184	0.248	0.019	0.021	0.203	0.269
4. Chicu	0.117	0.157	0.361	0.390	0.478	0.547
5. Frio	0.058	0.078	0.084	0.091	0.142	0.169
6. Subachoque (2)	0.346	0.466	0.228	0.247	0.574	0.713
Total	1.085	1.452	1.072	1.159	2.157	2.611

5.3 Development and Conservation Plan

5.3.1 Groundwater Development and Conservation Project in Eastern Hills of Bogotá Plain (Eastern Project)

(1) Project Area

Areas of this project are located in Eastern Hills that includes Soacha area, Vitelma area, San Diego area, Santa Ana & Chico area, Cerros Norte area, Yerba Buena and Suba area.

(2) Purpose of the Project

This project is environmental public works with purpose of water supply and improvement of water environment.

<Water supply for Bogotá City>

The volume of current water supply by EAAB to Bogotá City and neighboring cities is 15m^3/s. Volume of water supply is estimated to be 23m^3/s in the year 2015. The current water supply system of EAAB consists of three major systems, namely, ①Weisner System (Maximum treatment capacity: 12m^3/s), ②Tibitoc System (maximum treatment capacity: 11m^3/s), and ③Southern System (maximum treatment system: 2m^3/s).

Total volume of treatment capacity reaches to 25m^3/s. However, it is difficult to continue water supply of 25m^3/s because of fluctuation of water volume at each water resource and interruptions of operation for maintenance of purification plants. Especially, volume of current operation of Tibitoc purification plant is 6m^3/s. Considering water quality improvement of Bogotá river by increase of discharge, irrigation use and hydroelectric power generation, EAAB is planning to reduce operation volume to 2m^3/s in the near future though it is not decided when it will be implemented. Against such a background, development of new water resource for water supply is urgently necessary.

There is another subject on water supply in cases of emergency. Weisner System has vulnerability against natural disaster such as earthquake, because in this system water is conveyed from Chingaza Dam, which is located 40km from the purification plans, through water tunnel in mountain area. In 1997, water supply was stopped from this system during nine months. Moreover, development of new water resource in case of large-scale repairs of purification plants and pipelines are also important subject. Under the circumstances described above, groundwater of 2m^3/s (in ordinary cases: all year) and more than 4m^3/s (in emergency cases; assumed during 6 months and once/15 years) will be developed in proposed project.

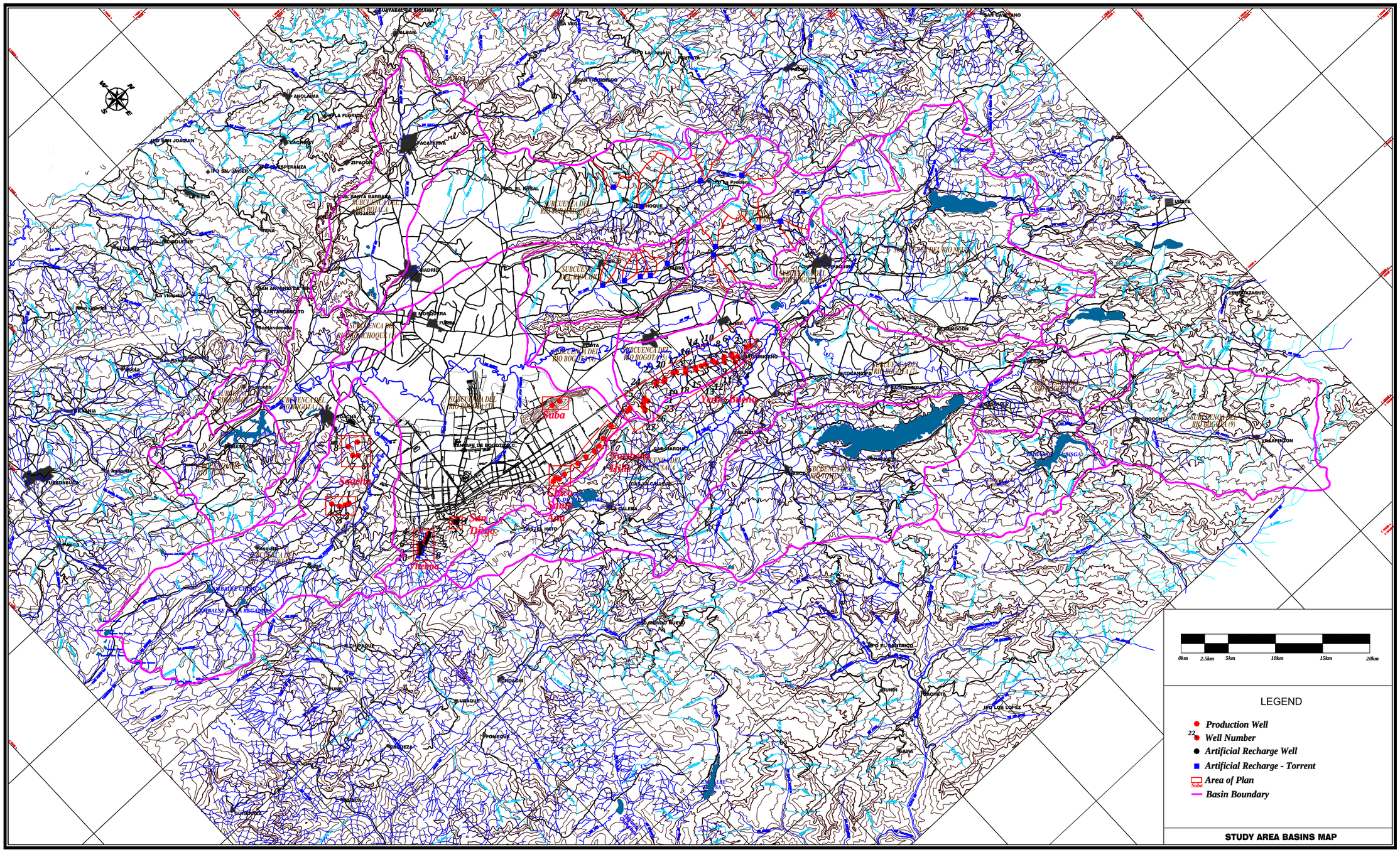

Figure-5.2 Well Plan for Development and Conservation of Groundwater

<Improvement of water environment>

New groundwater development for water supply will decrease water-intake at Tibitoc treatment plant. This decreased water-intake means increase of net discharge of Bogotá River and will contribute to improvement of water quality in Bogotá River.

Increased discharge of Bogotá River ①will increase dissolved oxygen and contribute improvement of water quality in the down-stream of Tibitoc purification plan, and ②will contribute to increase of hydroelectric generation at power station (Current operation of $20m^3/s$ for all year) that is located at down most of Bogotá Plain.

(3) Content of Project

Production wells are designed to achieve the objectives of the project considering groundwater potential and design water demand. Moreover, artificial recharge wells are designed for conservation of groundwater in the area. In this area, total volume of $0.5m^3/s$ can be used for artificial recharge, which is currently taken by Vitelma purification plant in San Cristibal River and San Diego plant of San Francisco River. This water will become surplus water for artificial recharge, because both plants have been decided to be out of use. However, in case of emergency, recharge wells will be used for production wells. Specification and number of production and recharge well is shown in Table-5.8. Well arrangement in each block is as follows:

<Cerros Norte area, Santana/Chico area, Suba Area, Soacha Area>

New wells will be drilled next to existing tank for water supply. Pumped groundwater will be stored in existing tank for usual and emergent water supply. Facilities for purification will be constructed beside existing tank.

<Vitelma Area and San Diego Area>

Production wells will be newly drilled along San Cristobal and San Francisco River. Groundwater pumped up form the wells will be used though newly constructed purification facilities using existing pipelines for usual and emergent water supply to Eastern Hills Area of Bogotá City and Soacha Area. Artificial recharge wells will be drilled near production wells to use surplus river water, which can be caused by abolition of Vitelma and San Diego purification plants. In cases of emergency, groundwater will be pumped up even from artificial recharge wells.

<Yerba Buena Area>

Production wells will be drilled in hills of Yerba Buena Area. Groundwater from wells will be joined to existing water supply system (Tibitoc – Bogotá City) though newly constructed purification facilities.

Table-5.7 Well Plan of Eastern Project

Area	Aquifer	Well size	Well number	Maximum Capacity (m^3/s)
Cerros Norte, Santana/Chico, Suba area. New wells will be drilled next to existing tank for water supply	Cretaceous	Well length: 300m Well diameter 10 inch Yield: 3,000m^3/day/well Injection: 3,000m^3/day/well	12	0.42
Soacha area. New wells will be drilled next to existing tank for water supply.			8	0.28
Vitelma and San Diego area.			Production wells: 13 Recharge wells: 13	0.45
Hills of Yerba Buena area, north of Bogotá City.			30	1.04
Total			Production wells: 63 Recharge wells: 13	<Production> Usual: 2.19 Emergency: 4.00 <Recharge> Usual: 0.45

(4) Beneficiaries of the Project

Population of direct beneficiaries by water supply in ordinary cases by project is 1.3 million. Population of beneficiaries by water supply in cases of emergency is more than 7.7 million that is the same as all population supplied by EAAB.

5.3.2 Groundwater Conservation Plan of Area of High Groundwater Use in Bogotá Plain (Western Project)

(1) Project Area

Area of this project is Subachoque River Basin, Chicu River Basin, Frio River Basin and area along middle reach to down-stream of Bogotá River, where groundwater is highly used. These areas are in western and center of Bogotá Plain, where groundwater is pumped up from Quaternary aquifers by more than 6,000 wells. In recent year, over-pumping is pointed out in these areas.

(2) Purpose of the Project

This project is environment public works with purpose of improvement of water environment as explained below:

<Groundwater recharge>

Purpose of this project is ① sustainable groundwater use without any trouble ② accumulation of groundwater potential for additional groundwater use in area where groundwater is highly used.

<Lightening of loads on groundwater resource caused by its use>

In order to reduce loads on groundwater resources in areas where groundwater is highly used, research and development of technology should be implemented to find practical methods. This study should include ①utilization of alternative water resource for irrigation including that for flower production ② improvement of efficiency in irrigation.

(3) Content of the Project

In order to achieve the purpose of the project, two sub-projects should be implemented, namely, ① groundwater recharge project and ② research and development of technology for groundwater use.

<Groundwater recharge project>

Artificial recharge should be implemented in up-stream of the area where pumping wells distribute. Water sources for artificial recharge will be river water of torrents in up-stream of the Subachoque, Chicu and Frio River basins. In these areas, river water is also highly used. Therefore, surplus water in floods in rainy seasons should be used for artificial recharge. Artificial recharge plan is shown inTable-5.8.

Table-5.8 Well Plan of Western Project

Area	Aquifer	Well size	Number of recharge well	Maximum recharge capacity
Subachoque Basin	Quaternary	Well length 300m Well diameter 10 inch Injection rate : 1,500m^3/day/well/2 sites	8 wells in 4 sites	0.14
Chicu Basin			10 wells in 5 sites	0.18
Up-stream of Frio Basin			10 wells in 5 sites	0.18
Total			28 wells in 14 sites	0.50

<Research and development of technology for groundwater use>

Technology for groundwater use will be researched and developed to reduce loads on groundwater resource caused by its intensive exploitation in the project area.

- Reuse of drained water of irrigation
- Use of rainfall for irrigation
- Use of surface water of Bogotá River for irrigation
- Transfer to new area for future projects of flower production
- Improvement of irrigation efficiency (including use of groundwater thermal property)

(4) Beneficiaries of Project

Population of beneficiaries of this project reaches 200 thousand that belongs to agricultural sector.

5.4 Monitoring Plan

Groundwater monitoring is necessary for Groundwater conservation. Monitoring items should include groundwater level, yields of wells and groundwater quality. Monitoring plan is summarized in Table-5.9. Monitoring wells should be selected taking account of the followings.

Table-5.9 Monitoring Plan

Item	Number of monitoring	Frequency of observation	Observation site	Purpose of Monitoring	Organization in charge
Groundwater level	12	Automatic recorder	Quaternary wells	- Long-term groundwater level fluctuation of Bogotá plain. - Result of artificial recharge in Bogotá Plain	EAAB
	10	Automatic recorder	Cretaceous wells	- Influence by groundwater development in Eastern Hills - Effect of artificial recharge in Eastern Hills	EAAB
	About 300	4 times/year	CAR monitoring wells	- Influence by artificial recharge in Bogotá plain - Groundwater level of Bogotá	CAR
	280	Once/month	Wells registered to DAMA	- Influence by groundwater development in Eastern Hills	DAMA
Yield	About 300	4 times/year	CAR monitoring wells	- Yield	CAR
	About 280	Once/month	Well registered to DAMA	- Yield	DAMA
Water quality	20	Twice/year	Sampling sites from 100 of JICA water quality analysis.	- Change of Water quality in Bogotá Plain	CAR
	10	Twice/year	-Wells near artificial recharge wells in Eastern Hills -Wells near artificial recharge wells in Bogotá Plain	- Change of water quality by artificial recharge	DAMA EAAB
Land Subsidence	12	Twice/year	12 Quaternary wells with JICA automatic recorders	-Land subsidence by lowering of groundwater level	CAR DAMA

(1) Groundwater level

Bogotá City Area

It is expected that groundwater levels will go down by groundwater development of the Eastern Hills. Lowering of groundwater levels, which will be observed by monitoring, should be compared with calculated ones. Development plan should be examined based on this result.

Bogotá Plain

Groundwater levels should be observed by monitoring wells that will be selected near artificial recharge wells (within 1km) in order to confirm effect of artificial recharge.

(2) Water Quality

It is necessary to analyze groundwater quality of wells near artificial recharge wells to identify influence by artificial recharge in Eastern Hills and western part of Bogotá plain.

(3) Land Subsidence

It is pointed that land subsidence is taking place by over-pumping in the Study Area. However, currently there is no data that proves the phenomena. Purpose for monitoring of land subsidence is to evaluate relation between groundwater levels and regional land subsidence. It is Quaternary Formations in the central and western part of Bogotá Plain that is the target of this monitoring.

5.5 Institution and Operation/Maintenance

(1) Water Resources and Groundwater Management

<Establishment of Joint Commission for Water Basin Management and Technical Commission for Groundwater Management>

Water resources in Bogotá Plain are managed by CAR and DAMA according to Law 99 of 1993. Regional Autonomous Corporation of Guavio also takes the charges in a quite limited area. Despite the concept of integrated water basin management, entities sometimes manages with their own standard and criteria, such as different levels of charges for water rights. As discussed in the meetings for problem identification, information on groundwater potential, water quality, volume of water abstracted, etc., is scattered in various related organizations. No entity has good understandings on the whole conditions on groundwater. Organizations in charge of the management are quite reluctant to give permissions for new development. In some central parts of Bogotá Plain, groundwater resource has been highly exploited and required measures for conservation of the resource have yet to be identified.

Establishment of a Joint Commission is required, as defined in Law 1604 of 2002. The composition of the commission members will be directors, or their delegates of, i) CAR, ii) DAMA, iii) Regional Autonomous Corporation of Guavio, iv)regional office for management of the national park, and Regional Autonomous Corporation of Magdalena River Basin. In the long term, however, members should be added by representative from other groups, including water users' associations, bulk water users such as water supply entities, municipalities and citizen groups such as NGO.

Establishment of a Technical Commission under and to support to Joint Commission is recommendable. The Technical Commission will be in charge of the followings:

- To integrate monitoring (volume of abstracted water, water level and quality) activities e and valuation on groundwater potential and availability
- To collect, analyze information on and to estimate the present and future demands for groundwater
- To make drafts of technical standards/guidelines for groundwater management
- To make investigations and recommendations on measures for groundwater protection, conservation and development

Members of the Technical Commission would be representatives or staff specialized for hydrogeology of i) CAR, ii) DAMA, as well as, national institutes such as iii) IDEAM, iv) INGEOMINAS, v) Major Users (EAAB, ASOCOLFLORES), vi) Colombian Association of Hydrogeologists, as well as vii) drilling companies.

<Operation for Monitoring and Evaluation>

Measurement and monitoring activities should be implemented by the CAR, DAMA and EAAB who manages monitoring wells. The Technical Commission should carry out analysis and evaluation of the data obtained from the monitoring.

As for data on volume of abstracted, it would better to compile data submitted from users into monitoring system. There are nearly 1,000 wells registered to CAR other than those designated as monitoring wells for the purpose. It is necessary to encourage for these well users to install meters and to submit the data on volume of abstracted water.

<Zoning and Tariff Setting for Demand Control and Saving of Groundwater>

For effective demand control and the resource conservation by promotion of saving water use, water pricing should take account of conditions of demand-supply. The Technical Commission or Group should prepare the draft of zoning and tariff setting based on the results of the Study and the monitoring and evaluation for the approval of the managing entity.

<Promotion of Well Registration and Establishment of Registration of Drillers>

Nearly 6,000 unregistered wells are estimated there in the Study Area. In case these wells are used, the use may be illegal. It is pointed out in the discussion meetings that there are many abandoned wells that may be contaminant source of aquifers. It is necessary to carry out investigation of unregistered wells and to let the users or owners to register in case in use or to scrap adequately in case out of use. For the investigation and execution, it is necessary to define legal procedures as well as to carry out legal arrangement to give staff of CAR and DAMA, or contractors, legal status, such as rights to pass to private lands and buildings.

For wells to be drilled, a system for registration of well drillers is recommendable in order to realize adequate applications for well drilling, construction works, pumping tests, applications for groundwater water abstraction. Since system of permissions for drilling might be strongly opposed by the existing drillers or might be recognized as deprivation of freedom to choose profession that is secured by the constitution, registration system is recommended without rejection of registration to any application. Every person who wants to do drilling business has to apply for registration with information of representative of the company, list of engineers and available equipment and financial status. In case some illegal actions, such as drilling without application or permission, construction works discarding to the permitted design, manipulation of data of pumping tests, are detected, the registration will be revoked and the person cannot drill for a certain period.

<Water Rights Application for Artificial Recharge>

In Colombia, there is no experience of artificial recharge projects same or similar as proposed in the plan, and no legal provisions are stipulated so far. There may be two options for application for water rights in artificial projects. It is necessary to get permissions by managing entities for implementation of the projects despite whichever options of water rights application are taken.

A) Water rights application is not to be done at times of surface water intake but at times of groundwater abstraction according to the volume abstracted. Artificial projects are not regarded as those to use water but those to conserve groundwater or to increase the availability of groundwater resources in this option.

B) The application is to be done at times of surface water intake and not application at times of groundwater abstraction. Recharged water is regarded as that stored in the ground by the surface water rights holders.

Since artificial recharge projects proposed in the plan have a nature of conservation of groundwater or amplification of groundwater availability for the times of emergency and dry seasons, option A would be recommendable for the projects of eastern hills and of the western plain. For the western plain project, entities managing of groundwater resource will implement

the project by itself and it will be quite natural for option A to be applied and for users to applied water rights when they abstract groundwater.

(2) Research and Development for Technology on Efficient Groundwater Use

<Establishment of Project Implementation Unit>

Since the nature of project of technical research and development (R&D) includes two major elements, i.e., water use for irrigation and the groundwater resource conservation, the project should be implemented by a unit established by CAR and ASOCOLFLORES. The two organizations should establish immediately a joint implementation unit for the project implementation.

Use of consultants is recommendable for the feasibility study of the project. In case international consultants are required, Ministry Environment should preferably apply technical assistance to foreign or international organizations. The Technical Commission or Group can work as internal consultants for advisor for the matter of the resource management. Participation of institutes for irrigation or agriculture should be encouraged especially for the component of the efficient irrigation with less groundwater.

<Financial Sources of the R&D Project>

As stipulated in Law No. 99 of 1993 as well as Decree No. 1729 of 2002, water right charges as well as surtax in immobile property destined to environmental and renewable natural resources conservation to be collected by the users should be used for the investment of the resource conservation. Additional funds should be complementally raised by the two organizations.

(3) Human Resource Development

To upgrade technical level of the staff engaged in groundwater management and development, the followings are recommendable.

<Technical Transfer through this Study and the Feasibility Study and by applying JICA Training Schemes >

Methodology adopted in and results of this Study should further studied by the counterparts. Through the feasibility study applied to the Government of Japan, entities in charge of groundwater management and development should take the opportunity for technical transfer from experts to be dispatched. Since JICA has prepared various training courses, entities in charge of groundwater management and development can be utilized them for technical transfer.

<Mutual Edification through Activities in the Technical Commission >

Technical upgrade can be realized through activities in the Technical Commission recommended above by exchanging information and mutual edification among the commission members. One of the major reasons for the proposal for the establishment is technical level up of the staff. Seminars for the drillers by the Technical Commission may contribute not only to technical upgrade but also to sound groundwater development.

<Scholarships>

For upgrade of technical level to higher level in the field of hydrogeology, scholarships can be recommended for the young staff of CAR, DAMA, etc., to study in master courses or Ph. D. courses in Colombian or foreign universities. It can be proposed for IDEAM to give opportunity for the staff all over the country in charge of groundwater management by preparing a scheme for scholarship especially for those who want to study abroad. Scholarship should be repaid when the persons will leave public entities for water resources management

within a certain period, say five to ten years after the persons finish the study.

5.6 Design and Cost Estimate

5.6.1 Design

(1) Design Criteria

In Colombia, according to the well drilling work, the civil work, concrete structure work and the electric installation work, the following design criteria are applied. These criteria depend on those of the USA. The designs in the Master Plan Study follow these criteria.

(a) Well drilling work: AWWA-100(1997)

(b) Civil work:

Road construction work: Normas Invias
Installation of pipe work: Reglamento Técnico del sector de Agua Potable y Saneamiento Básico RAS – 2000

(c) Concrete structure work:

Normas Colombianas de Diseño y Construcción Sismoresistente NSR – 98

(d) Electric work: Código Eléctrico Nacional Colombiano CEC

Installation of power supply work
Installation of electric facilities

(2) Capacity of Well

Arrangement of production and recharge wells is designed based on size and capacity of standard well as shown in Table-5.10.

Table-5.10 Standard Capacity of Wells

Type of well	Aquifer	Length of well	Diameter of well	Specific/injection Capacity
Production well	Quaternary	200-300m	8 inch	1,500m^3/day
	Cretaceous	300m	10 inch	3,000m^3/day
Recharge well	Quaternary	200-300m	10 inch	1,500m^3/day
	Cretaceous	300m	10 inch	3000m^3/day

(3) Design of Facilities

The principal facilities for the proposed two projects, namely, groundwater development and conservation in Easter Hills of Bogotá Plain, and groundwater conservation project in Western part of Bogotá Plain are shown in Table-5.11 and Table-5.12.

Table-5.11 Facility Design － Groundwater Development and Conservation Project in Eastern Hills of Bogotá plain

Location	Facilities	Size	Unit	No
Soacha	Production well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	8
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	8
	Electric Facilities	Incoming line	m	3,200
	Pipeline	Diameter: 150mm	m	2,400
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：18,000m^3/day	No	2
Vitelma (San Cristobal River)	Production well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	10
	Production/recharge well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	10
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	20
	Electric Facilities	Incoming line	No	3,200
	Pipeline	Diameter: 150mm	m	2,400
	Settling pond	Capacity: 30,000m^3/day	No	1
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：90,000m^3/day	No	1
San Diego (San Francisco River)	Production well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	3
	Production/recharge well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	3
	Submersible Pump	For 10inch well-75KV, H=150m,Q=4,500m^3/day	No	6
	Electric Facilities	Incoming line	m	250
	Pipeline	Diameter：150mm, 250mm, 300mm (Total)	No	900
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：27,000m^3/day	No	1
Santa Ana & Chico	Production well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	4
	Submersible Pump	For 10inch well-75KV, H=150m,Q=4,500m^3/day	No	4
	Electric Facilities	Incoming line	m	900
	Pipeline	Diameter: 150mm	m	800
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：18,000m^3/day	No	1
Cerros Norte	Production well	Diameter/length : 10inch/150m+8inch/150m (300m)	No	6
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	6
	Production well	Incoming line	m	2,450
	Pipeline	Diameter: 150mm	m	1,750
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：27,000m^3/day	No	1
	Access road	4m width	m	200
Suba	Production well	Diameter/Length: 10inch/150m+8inch/150m (300m)	No	2
	Submersible Pump	For 10inch well-75KV, H=150m, Q=4,500m^3/day	No	2
	Electric Facilities	Incoming line	m	200
	Pipeline	Diameter: 150mm	m	600
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：9,000m^3/day	No	1
Yenoba Bueno	Production well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	30
	Submersible Pump	For 10inchwell-75KV, H=150m, Q=4,500m^3/day	No	30
	Electric Facilities	Incoming line	m	20,000
	Pipeline	Diameter: 150mm, 250mm, 300mm (Total)	m	20,500
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：45,000m^3/day	No	3
	Acess road	4m width	m	17,100
	Site (well)	30m x 30m	No	30
	Site (Purification)	30m x 30m	No	3
total	Production well	Diameter/Length: 10inch/150m+8inch/150m (300m)	No	63
	Production/Recharge well	Diameter/Length: 10inch/150m+8inch/150m (300m)	No	13
	Purification facilities	Aeration＋settling pond＋Chlorination Maximum capacity：45,000m^3/day	No	10

Table-5.12 Facility Design—Groundwater Conservation Project in Western Part of Bogotá Plain

Location	Facilities	Size	Unit	No
<Torrent Recharge project>				
Chic Basin (5 sites) Frio Basin (5 sites) Subachoque Basin (4 sites Total：14sites	Weir	Size 2x4x1m, Intake0.3x1m	No	14
	Channel	0.3x0.3x10m	m	14
	Settling Pond	Capacity 30,000m^3(100mx100mx3m)	No	14
	Purification	Purification instrument 3units	No	14
	Regulation tank	Capacity 20m^3	No	14
	Recharge well	Diameter/length: 10inch/150m+8inch/150m (300m)	No	28
	Submersible pump	For 10inchwell-7.5HP, H=150m, Q=500m^3/day	No	28
	Site	10,900m^3	No	14

5.6.2 Cost Estimate

Cost of the two projects proposed in the Master Plan, i.e., 1) Groundwater Development and Conservation in Eastern Hills of Bogotá Plain, 2) Groundwater Conservation in Western Part of Bogotá Plain, are roughly estimated as follows:

* Cost Estimate Standards: CONSTRUDATA CIELOS RASOS 124 SEPTIEMBRE NOVIEMBRE 2002, PUBLI LEGIS
* Unit Cost: As in July
* Exchange Rate: US$ 1 = Col.$ 2,700 (reference JPY 1 = Col.$ 20

Project costs are comprised of the following. Tax (IVA) is included in each element.

* Construction Cost: Cost for construction of main facilities and auxiliary Facilities including preparatory works and installation of equipment (Cost for; Materials + Equipment + Labor + Administration + Profits).
* Land Acquisition Cost: Cost for acquisition of land required for facility construction, including compensation cost.
* Engineering Fee: Fee to be paid to consultants required for tendering, detail design and cost estimate. 10% of the construction cost.
* Administration Cost: Cost for project owner to administer the project. 1% of costs for construction, land acquisition, and engineering.
* Contingency: 10% of costs for construction, land acquisition, engineering, and administration.

Project cost of two projects that was estimated under above condition is shown as follows. See Table-5.13.

- Groundwater development and conservation project in eastern hills of Bogotá plain
  Project cost: 75.43 billion Colombian pesos
- Groundwater conservation project in western part of Bogotá Plain
  Project cost：40.48 billion Colombian pesos

Table-5.13 Rough Cost Estimate—Groundwater development and Conservation in Plain

unit：Billion Col$

Item	Groundwater development and conservation project in Eastern hills	Groundwater conservation project in western area	Total
1. Construction cost	60.36	25.60	85.96
2. Research	-	9.00	9.00
3. Land Acquisition cost / compensation	1.65	0.20	1.85
4. Engineering fee	6.04	2.56	8.60
5. Administration cost	0.67	0.28	0.95
6. Contingency	6.71	2.84	9.55
＜Total＞	75.43	40.48	115.91
	27.9 million US$	15.0 million US$	42.9 million US$
	3,770 million Japanese yen	2,030 million Japanese yen	6,900 million Japanese yen

Note) IVA is included in each item.

5.7 Implementation Program

(1) Organization for Implementation and Preparation of Fund

Organizations for implementation and preparation of funds for the two projects proposed by the Master Plan; i.e., ①Groundwater development project in Eastern Hills of Bogotá Plain, ② Groundwater conservation project in western part of Bogotá Plain, are proposed below.

Groundwater development and conservation project of Eastern Hills of Bogotá Plain

Ministry of Environment should supervise this project, because this is an integrated environmental project that is planed in two administrative areas (Cundinamarca Department and Bogotá City). Organization in charge of this project should be Bogotá City that will receive direct benefit (water supply for Bogotá City) from this project. Implementation organization should be Water Supply and Sewerage Company of Bogotá (EAAB) that is invested 100% of its capital by Bogotá City.

Funds for implementation (75 Billion Pesos) should be from environmental investment of Bogotá City, and it should be taken into account to use foreign funds (soft roan) for most part of implementation.

Groundwater conservation project in western part of Bogotá Plain

Ministry Environment should supervise this project as well as above mentioned project. CAR, which takes responsibility of environmental projects in Cundinamarca Department, is suitable for organization in charge of this project. Implementation organization should be joint implementation unit (CAR and ASOCOLFLORES): Organizations to receive benefit from this project) that will be newly organized.

Funds for implementation (40 Billion Pesos) should be from environmental investment of CAR, and it should be taken into account to use investment fund from members ASOCOLFLORES and foreign funds (soft roan) for considerable part of implementation.

(2) Implementation Schedule

Implementation schedule of groundwater development/conservation project and institutional project on groundwater management and etc is proposed as shown in Table-5.14. Before implementation of two environmental projects: ①groundwater development and conservation project and ②groundwater conservation project in western part of Bogotá Plain, 2 to 3 years are necessary for preparation works (F/S and procurement of consultant/construction

company).

Table-5.14 Implementation Schedule of the Project

Item	Year	00	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15
1	**Project in Eastern**																
1-1	Preparation																
A	M/P and F/S	X	XX	XX	XX	XX											
B	Procurement																
	- Consultant						X										
	- Construction company						X										
1-2	Consultant Service																
A	Survey/Design/Cost Estimate						X										
B	Supervising of construction							XX	XX	XX	XX						
1-3	Construction (76wells)																
2	**Project in Western**																
1-1	Preparation																
A	M/P and F/S	X	XX	XX	XX	XX											
B	Procurement																
	- Consultant						X										
	- Construction company						X										
1-2	Consultant Service																
A	Survey/Design/Cost Estimate						X										
B	Supervising of construction							XX	XX	XX	XX	XX	XX	XX			
1-3	Construction																
	Project of Torrent Recharge (14 sites)							XX	XX	XX	XX	XX	XX	XX			
3	**Institutional Projects**																
3-1	Preparation	X	XX	XX													
3-3	Groundwater monitoring				XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX
3-3	Establishment of technical commission for groundwater management				XX	XX											
3-4	Activity of technical commission						XX	XX	XX	XX	XX	XX	XX	XX	XX	XX	XX

5.8 Initial Environmental Examination

(1) The study team have decided that a comprehensive environmental impact assessment is necessary for attempting groundwater development through a screening process on environmental factors.

(2) Then by scooping process, the study team also decided that following environmental factors should be carefully examined in the assessment.

- Possibility of contamination of groundwater following artificial recharging
- Possibility of lowering water table and interferences raised among existing wells with withdrawal of groundwater
- Possible subsidence of ground surface by withdrawal of groundwater

5.9 Project Evaluation

5.9.1 Economic Evaluation

(1) Assumptions for Economic Evaluation

On estimating the economic cost and benefit, the principal assumptions as presented in Table-15. are applied.

Table-5.15 Principal Assumptions

Items	Assumptions	
1.Prices	As of July 2002	
2.Exchange Rate of Colombian Peso	Col$ 2,700 = US$ 1.00	
3.Opportunity Cost of Capital	13 % (Based on the study by World Bank in Colombia)	
4.Standard Conversion Factor	96 % (Based on the external trade of Colombia from 1996 to 2002)	
5.Time Horizon for Evaluation	20 years (Based on economic of well)	
6.Economic Life (Principally based on EAAB Accounting Standards)	1) Weir: 50 years	2) Sedimentation Pond: 50 years
	3) Well: 20 years	4) Treatment Facilities: 50 years
	5) Canal: 50 years	6) Electric Facilities: 20 years
	7) Pumping Motor: 8 years (to be replaced periodically in 8 years)	

(2) O&M Cost

O&M (Operation and Maintenance Cost) of 2 projects is estimated based on the assumptions in Table-5.16.

Table-5.16 O&M Cost

Project	Assumptions
1) Bogotá Eastern Hill Project	1) Electricity
	- Consumption: 74 kwh/day/well
	- Price: Col$87kwh (same as price of Vitelma in 2000)
	2) Chlorine
	- Consumption: 70% of Wiesner (0.00229/m^3)
	- Price: Col$1,094/kg
	3) Groundwater Charge: Col$15/$m^3$
	4) Maintenance: 2% of 1)+2)
2) Bogotá Western Plain Project	2% of project cost

(3) Benefit

The benefit is estimated based on the assumptions in Table-5.17.

(a) Bogotá Eastern Hill Project

1. Emergency Water Supply: Groundwater supply volume in emergency is counted as benefit.
2. Regular Water Supply: Groundwater supply volume developed by the Project is counted as benefit. However, benefit can be counted only from 2018 when groundwater shortage against demand is foreseen.
3. Dissolved Oxygen Increase in Bogotá River: Groundwater development will decrease Tibitoc Plant intake from Bogotá River. The decreased volume could be discharged into Bogotá River in order to improve its water quality and irrigate. The reduction of Biological Oxygen Demand (BOD) in the Bogotá River Basin after the location of Tibitoc Plant can be counted as the benefit.
4. Incremental Electric Generation at Bogotá River: Besides, the discharged water will contribute to increase electric-power production of the power plant located at the lowest course of Bogotá River stream. Hence, incremental GDP resulted from increased electric power will be counted as the benefit, from 2014 when electric power shortage is foreseen.

Table-5.17 Assumptions for Benefit (Eastern Hill Project)

Benefit	Assumptions
1. Emergency Water Supply	1) Supply Volume: 4.0 m^3/s
	- 63 production wells: 3.3 m^3/s (=2.19 m^3/s x 150%)
	- 13 recharging wells: 0.7 m^3/s (=0.45 m^3/s x 150%)
	2) Water Price: 1,500 Col$/$m^3$ (EAAB average price of Jan-April 2002)
	3) Magnitude of Emergency (Accident)
	- Frequency: every 15 year since 1997
	- Water Supply Stop: 6 months considering 3-month water stock of San Rafael Reservoir
2. Regular Water Supply	1) Supply Volume: 2.0 m^3/s (=2.19 m^3/s x 90%) from Year 2018 when EAAB water production shortage against demand can be foreseen.
	2) Water Price: 1,500 Col$/ m^3 (Average price of Jan-April 2002)
3. Dissolved Oxygen Increase effect in Bogotá River	1) Present BOD concentration:15,13,50,250,90 and 49mg BOD/l at 6 locations
	2) Increased Dissolved Oxygen: Proportional to the increased water volume of by the ratio of 1.6 O_2 2mg^3/second water (web site of CTI Science System Co. Ltd)
	3) Unit Cost: 0.005 Col$/mg BOD (Salitre Waste Water Treatment Plant: 648 Col$ /125,000 mg BOD)
4.GDP increase by contribution of incremental electric power at Bogotá River Basin	1) GDP contribution of electricity: 1% (=70% of 1.5% in Japan)
	2) Year 2002 GDP estimation: 190 Col$ trillion
	3) Contribution from year 2014 when electric power shortage is assumed against demand.

(b) Bogotá Western Plain Project

The available water volume is converted to cultivated area (ha) expansion. Floriculture industries contribution to agriculture GRDP of Cundinamarca is counted as the benefit of this project. Assumptions are shown in Table-5.18.

Table-5.18 Assumptions for Benefit (Western Plain Project)

Benefit	Assumptions
Floriculture Contribution to GRDP Increase	1) 3% of Annual Recharged Water for Floriculture Irrigation Use
	2) Conversion to cultivated area (ha) taking into account floriculture use (0.3l/s/ha)
	3) Agriculture GRDP of Cundinamarca: 2.7 Col$ trillion
	- Floriculture contribution : 50% to GRDP

(4) Result of Economic Evaluation

Economic evaluation of 2 projects is conducted applying all criteria mentioned above. The results of economic evaluation are summarized in Table-5.19. EIRR of Bogotá Eastern Hill Project and Bogotá Western Plain Project results respectively in 22% and 21% that exceed 13% of opportunity cost of capital. Consequently it is noted that the Projects are feasible from economic point of view.

Table-5.19 Result of Economic Evaluation of the Two Projects

Project	EIRR	Net Present Value	B/C
Bogotá Eastern Hill Project	22%	Col$ 79.2 billion	1.9
Bogotá Western Plain Project	21%	Col$ 12.9 billion	1.3

5.9.2 Financial Analysis

(1) Bogotá Eastern Hill Project

(a) Revenue

Developed groundwater can be used for emergency supply. Moreover, groundwater will be supplied routinely for the purpose of substituting a part of production of Tibitoc Plant where the

production cost is deemed too high. Accordingly the production cost of Tibitoc Plant (as presented in Table-5.20) corresponding to groundwater supply volume is obviously recognized as financial revenue over the period of substituting purpose. Financial revenue will be fully derived from groundwater supply volume from 2018 afterward when EAAB water supply shortage is foreseen.

Table-5.20 Estimated Variable Cost of Tibitoc Plant

Items	Cost (Col$/m^3)	Remarks
Electricity	45	Actual cost of year 2000
Chemical	21	Twice as large as Vitelma of year 200
Water Charges	120	Assumed from actual case
Depreciation	50	Concession fee minus chemical cost (year 2000)

(b) Result of Financial Evaluation

14% of opportunity cost of capital is applied in this study based on the EAAB standards. Result of Evaluation is summarized in Table-5.21. FIRR (Financial Internal Rate of Return) of Bogotá Eastern Hill Project results in 23% that obviously exceeds 14% of opportunity cost of capital. Consequently this project is feasible from financial point of view.

Table-5.21 Result of Financial Evaluation of Bogotá Eastern Hill Project

Project	FIRR	Net Present Value	B/C
Bogotá Eastern Hill Project	23%	Col$ 63.0 billion	1.7

(c) Funds Scheme for Project Cost

Total project cost will amount to Col$ 75.4 billion (US$ 27.9 million). Bogotá Eastern Hill Project is obviously environmental project as well. Taking it into account, funds for project cost could be raised from foreign soft loan. Accordingly, the funds composition is proposed as follows;

- Own Funds of Implementation Organization (EAAB)	: 20%	Col$17.1 billion (US$ 6.3million)
- Foreign Soft Loan	: 80%	Col$58.3 billion (US$21.6million)

Note: Land acquisition cost and administration cost are excluded from Foreign Soft Loan.

(2) Bogotá Western Plain Project

<Implementation Organization and Funds Composition>

Joint implementation between Government and groundwater users (principally flower cultivators associated with ASOCOLFLORES) is proposed in execution of the Project. The Project does not aim to recover its cost, so that the funds for the Project consist of investment or subsidies. Accordingly, the funds composition is proposed as shown in Table-5.22.

Table-5.22 Implementation and Funds Scheme

Joint Partners	Funds Shares	Fund Resources	Remarks
Government	70%	Groundwater Charges	For the most part, charges collected from flower cultivator
		Investment or Subsidies	Possible to be raised from foreign soft loan by reason of environmental project
Users (Principally ASOCOLFLORES)	30%	Investment or cost sharing	Spontaneous contribution by ASOCOLFLORES members

5.9.3 Social Evaluation

The following social benefits are expected from the Projects.

(1) Bogotá Eastern Hill Project

<To Secure Water in case of Emergency >

Groundwater development enables EAAB to secure and supply water in case of emergency such as large accident/disaster of Chingaza and droughts. Especially inhabitants at Eastern Hills of Bogotá City and Suba receive a great benefit from groundwater development because current system is unable to distribute water to such higher places from main aqueducts of Tibitoc line.

<Construction of Water Supply Facilities at Soacha Region>

Development plan area is located at hills of Soacha where inhabitants live in poverty and population has been growing rapidly. Groundwater development corresponds with strong request of inhabitants to construct water supply facilities.

<To Secure Forests Fire Fighting Water>

Forest fires occur at Eastern Hills every year especially during dry season from January to February. The Project plans to construct many tanks and distribution pipes, which could offer a significant increase of intake places for fire fighting activities.

(2) Bogotá Western Plain Project

The following effects are estimated, which bring a great benefit to flower cultivators and agriculture farmers who mostly depend on groundwater.

- To prevent from lowering of groundwater level
- To generate incremental availability of groundwater use
- To secure irrigation water to some extent in case of drought

(3) Integrated Effects

An increase of employment opportunity and activation of regional economy are expected. The employment effect in monetary basis by the Projects is estimated at Col$1.3billion from Bogotá Eastern Hill Project and at Col$2.6billion from Bogotá Western Plain Project.